INVESTIGATION OF POSSIBLE EFFECTS ON THE MARINE ENVIRONMENT OF DREDGING AND FILLING THE RAGGED KEYS

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Report to the Florida State Board of Conservation
October 1958

The Marine Laboratory of the University of Miami, at the request of the Florida State Board of Conservation, has investigated the site of a proposed bulkhead and fill project that would consolidate the Ragged Keys, 1, 2, 3, 4, and 5, in southern Biscayne Bay, Dade County, Florida. In the present investigation new observations were made and results of past biological surveys of the area compiled.

The study involved the bulkhead line as described by James W. Moore, in his application for fixing bulkheading lines to the Board of County Commissioner of Dade County.

While the effect of changes in the water current patterns in connection with the biology of the area is discussed, no attempt has been made to evaluate the hydraulic problems involved in filling natural tidal channels which allow water exchange between Biscayne Bay and the ocean, although these might have important consequences.

DESCRIPTION OF THE RAGGED KEYS

The Ragged Keys, a chain of six small islands, lies on the eastern edge of Biscayne Bay about eight miles south of the Cape Florida light on Key Biscayne (Figure 1). They are approximately seven miles from the mainland.

The upper Keys and the shallow flats surrounding them form a protective barrier against the wave action of onshore seas resulting from the prevailing southeasterly winds. They are prominently marked by tidal channels which run roughly east and west across the barrier. These channels through the Ragged Keys and submerged bars to the north have been called "safety valves," since they allow water exchange between bay and ocean and prevent excessive pileup of water within Biscayne Pay during periods of high winds and spring tides.

The mean range of tides varies between 1.9 and 2.3 feet in the Ragged and Soldier Keys area, with the latter figure being the average range during periods of spring tides.

SALINITY

There are no seasonal data pertaining to salinity in the Ragged Keys but there are such data for Soldier Key immediately to the north. Since these areas are so close, the Soldier Key readings are pertinent to the present study (Table 1).

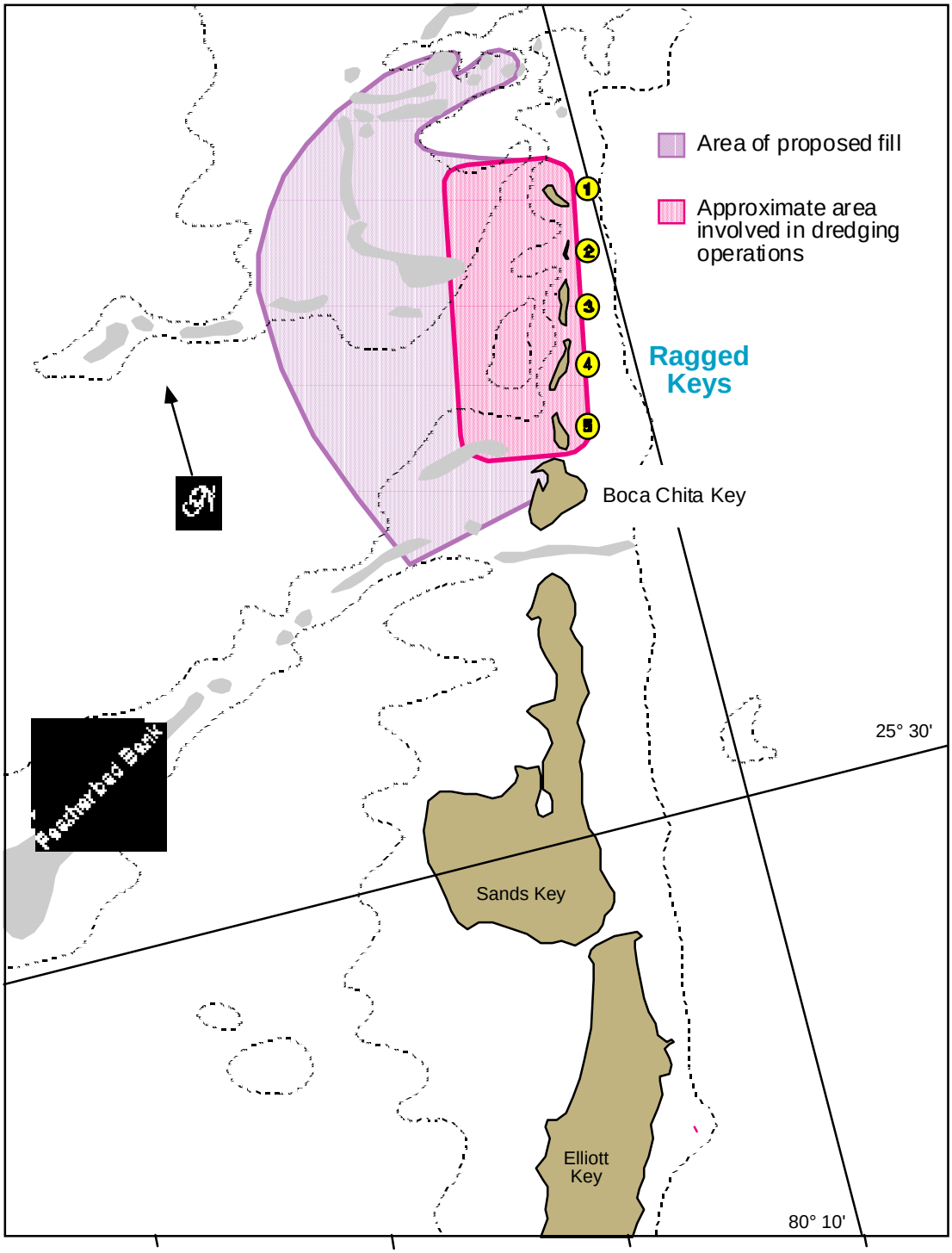

Figure 1. Section of Biscayne Bay showing the Ragged Keys and surrounding marine areas. The hatched area is that to be included within the proposed bulkhead line.

Table 1. Surface water temperatures in degrees Centigrade and surface salinity in grams per kilogram for Soldier Key.

Date	Water Temp. (C°)	Salinity in (ppt)
7/7/45	31.7	37.11
8/4/45	30.5	36.67
10/27/45	24.7	33.06
12/2/45	19.58	33.91
1/6/46	21.79	36.22
2/3/46	23.23	36.26
4/28/46	25.15	36.86
6/6/46	28.13	35.70

The salinities observed at the Ragged Keys during August, 1958, ranged between 37 ppt and 38 ppt, and temperatures ranged between 30° and 31° C. The slightly higher values for both salinity and temperature found in the Ragged Keys were, of course, obtained at different times, but may be the result of a generally higher rate of evaporation and greater warming in the shallows to the west and south of these islands. It is suspected that water exchange in the bay in the vicinity of the Ragged Keys is less complete than that found to the north opposite the numerous tidal channels of the submerged banks between Key Biscayne and Soldier Key.

Closure of existing tidal channels would create conditions of poorer circulation, higher salinities and greater temperature extremes within the portion of the bay opposite the Ragged Keys, in the area around Featherbed Bank. The biological implications of such change will be discussed in the sections dealing with plant and animal distribution.

BOTTOM TYPES

Five major categories of bottom or substrate materials have been noted in the Ragged Keys and adjacent submerged areas (Figure 2). These are as follows:

1) Key Largo limestone, the eroded bedrock of the Ragged Keys and adjacent islands that is exposed in many places in the intertidal zone of the Keys as well as in the tidal cuts between the Keys.

2) Coarse rock and coral fragments in a soft matrix of shell fragments, marl and calcareous sand, found on the seaward side of the Keys out to a depth of 10 to 12 feet.

3) White, coarse, well sorted calcareous sand and shell fragments found in the deeper tidal channels. Occasionally this sand may be studded with outcroppings of the bed-rock.

4) Pine gray calcareous marl and shell fragments forming the substrate of the extensive submerged flats on the bay side of the Ragged Keys. This substrate material may intergrade with Type 2 in the immediate vicinity of the Ragged Keys, thus allowing mixing of the Bay and offshore platforms.

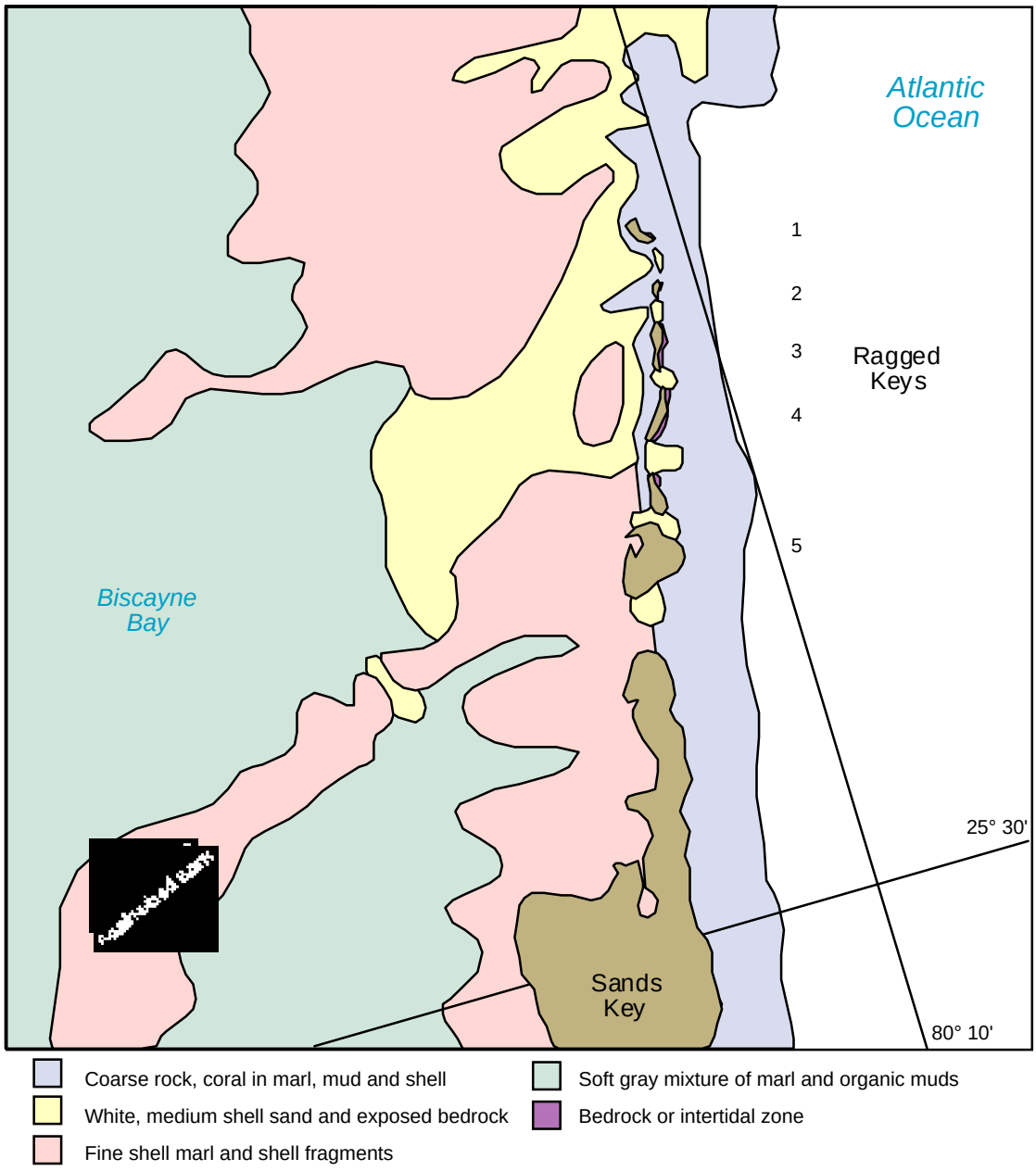

Figure 2. Semidiagrammatic presentation of the five major bottom materials of the Ragged Keys and adjacent areas.

5) Soft, fine-grained marl and organic mud mixture, gray to brown in color, found in the deeper, more quiet portions of the bay west of the Ragged Keys.

The transition between bottom materials may be abrupt or gradual. A gradual transition is illustrated in Figure 2 above. Abrupt transition between bottom types is seen at the edges of the tidal channels that bisect the shallow flats west of the Keys. In these areas, currents have cut and sorted bottom materials to a marked degree and result in distinct animal and plant zonation.

CURRENTS

The configuration of the Ragged Keys and adjacent areas is the result of wave and current erosion (Figure 3).

The tendency for oceanic waters to "pile up" behind barrier islands is well known. In the Indian River lagoon of the central east coast of Florida, the water level in the lagoon may rise as much as four feet above mean sea level. This phenomenon is a result of the inability of the inlets to handle water placed behind the barrier islands by winds from the east and southeast and during periods of excessive rainfall runoff from the interior.

The channels between the Ragged and adjacent Keys are results of the movement of water on the daily tidal cycle and are vital in equalizing water levels between bay and ocean.

The currents now passing through the Ragged Keys have a major influence upon the biological welfare of the Bay. The currents distribute oxygen-rich waters from the grass flats; they carry the organic material necessary to the existence of filter feeding animals such as the mollusks, coral animals, marine worms and crustaceans, and they tend to equalize the temperatures within the bay during periods of temperature extremes.

The currents also provide a myriad of ecological niches by their sorting action upon the bottom material. Once the currents have created a favorable sub-stratum, they insure a supply of food and a supply of eggs and larvae to surrounding areas. Destruction of the established current flow patterns in the Ragged Keys will have an effect upon plants and animal distribution beyond the immediate confines of the area to be dredged and filled. It cannot be determined in advance what the ultimate result will be. We know from pollution studies, however, that biological conditions in northern Biscayne Bay have steadily worsened as land development has progressed. Changing current patterns as a result of dredging and filling have combined with industrial and sewage pollution in northern Biscayne Bay, creating areas of stagnation and animal and plant disappearance.

MARINE PLANTS

Surveys of the Ragged Keys have shown this to be one of the richest areas within Dace County waters for marine algae (Table 2). The marine grass *Thalassia testudinum* also occurs in great density on the bay flats adjacent to and west of this group of Keys.

There are two broad zones of marine plant life within the study area: *Thalassia* carpeting the quieter shallows of the bay and the algae community occupying the ocean side of the Keys. In suitable areas of substrate material there is some intermixing of algae and grass (Figure 4).

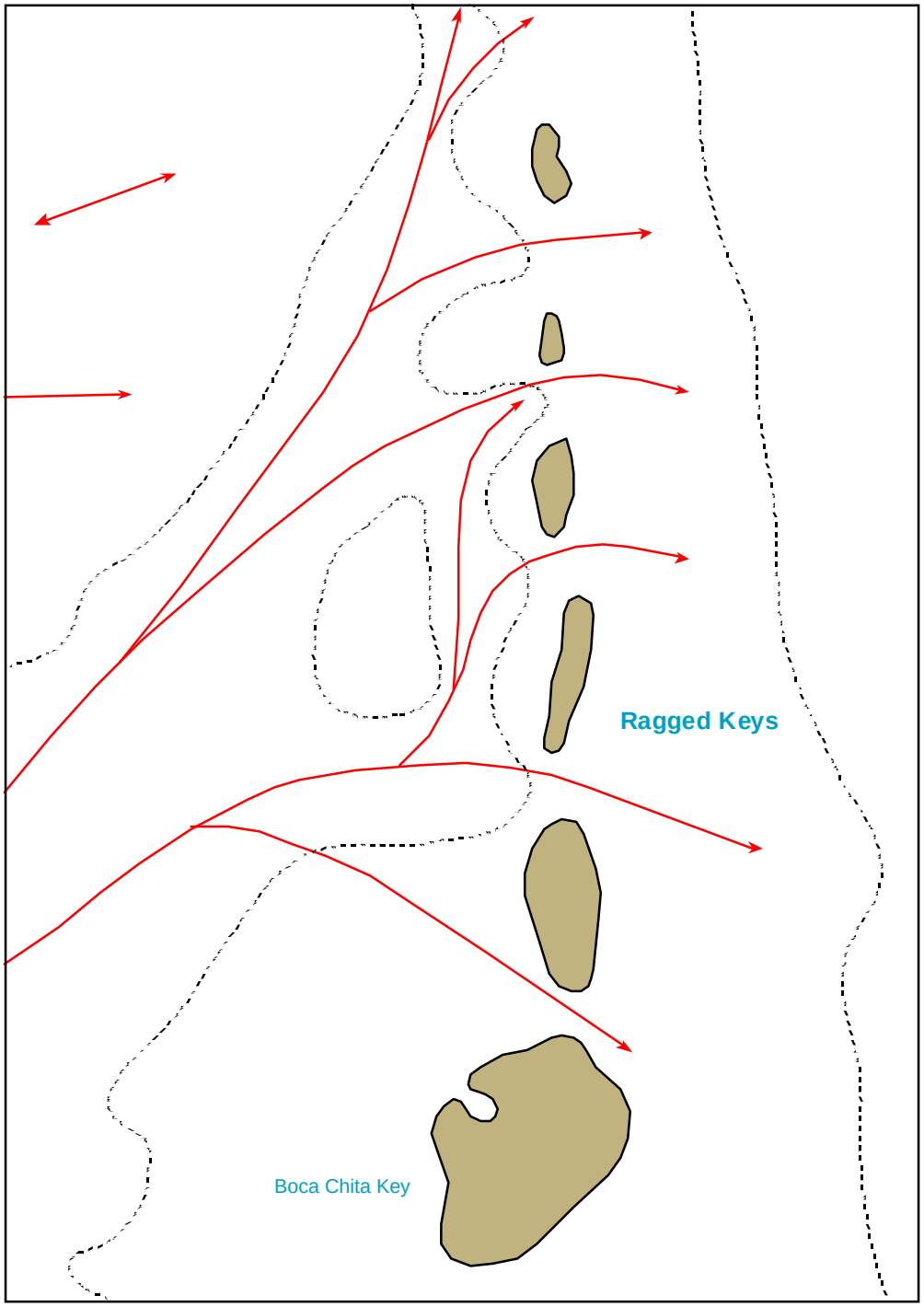

Figure 3. Overlay showing main current patterns in the Ragged Keys.

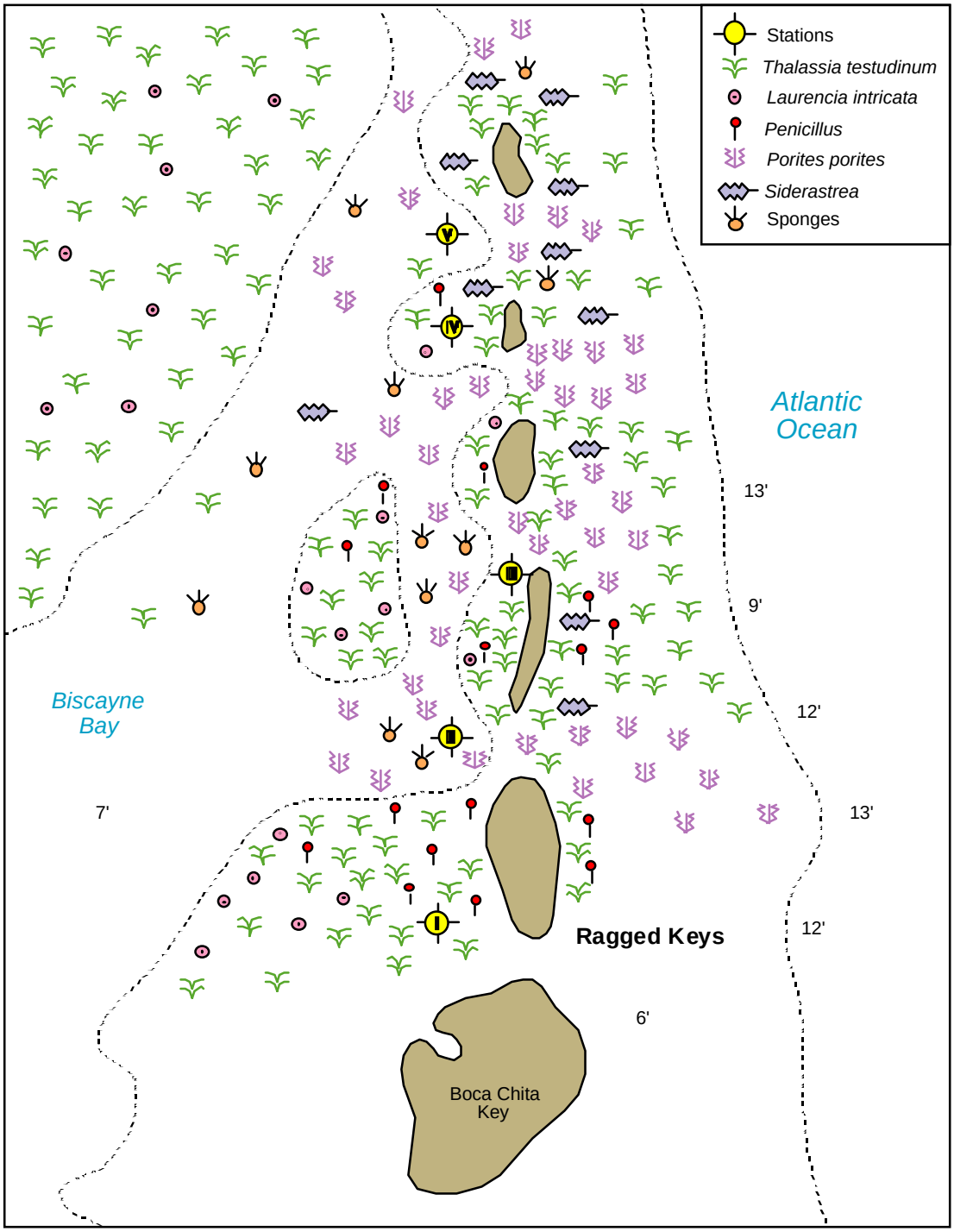

Figure 4. Semidiagrammatic map of the Ragged Keys illustrating the main life zones of the area in relation to depth, substrate and current patterns.

Table 2. List of the algae known to occur in the immediate vicinity of the Ragged Keys.

GREEN ALGAE	RED ALGAE
Cladophora repens (J. Agardh) Harvey	*Jania* sp.
Anadvomene stellata (Wulfen) C. Agardh	*Bostrychia tenella* (Vahl) Kuntze
Cladophoropsis macromeres Taylor	*Lithothamnia* sp.
Caulerpa cupressoides (West) C. Agardh	*Laurencia intricate* Lamouroux
Caulerpa prolifera (Foerskal) Lamouroux	*Laurencia papillosa* (Foerskal) Greville
Caulerpa racemosa (Foerskal) J. Agardh	*Laurencia poitei* (Lamourcux) Howe
Caulerpa sertularioides (Gmelin) Howe	*Laurencia obtusa* (nudson) Lamouroux
Caulerpa paspaloides (Bory) Greville	*Euchemma isiforme* (C. Agardh) Harvey
Halimeda discoidea Decaisne	*Bypnea cornuta* (Lamouroux) J. Agardh
Halimeda monile (Ellis and Solander) Lamouroux	*Champia parvula* (C. Agardh) Harvey
Halimeda opuntia (Linnaeus) Lamouroux "	*Acanthophora spicifera* (Vahl) Borgesen
Halimeda tridens (Ellis and Solander) Lamouroux "	*Xeterosiphonia Gibbesii* (Harvey) Falkenberg
Halimeda simulans Howe	*Crouania attenuate* (Bcnnemaison) J. Agardh
Udotea conglutinata (Ellis and Solander) Lamouroux	*Amphiroa fragillissima* (Linnaeus) Lamouroux
Udotea flabellum Ellis and Solander) Howe	*Amphiroa rigida* Lamouroux
Penicillus capitatus Lamarck	*Goniolithon strictum* Fcslie
Penicillus dumetosus (Lamouroux) Blainville	BROWN ALGAE
Dasycladus vermicularis (Scopdi) Krasser	*Dictyota dichctoma* (Xudson) Lamouroux
Valonia ocellata Howe	*Dictyota divaricata* Lamouroux
Valonia ventricosa J. Agardh	*Dictyota pardalis* Kuetzing sensu Borgesen
Dictyosphaeria cavernosa (Foerskal Borgesen	*Dictyota bartayresii* Lamouroux
Rhipocephalus phoenix (Ellis and Solander) Kuetzing	*Dictyota cervicornis* Kuetzing
Rhipocephalus oblongus (Decaisne) Kuetzing	*Sargassum vulgare* C. Agardh
Avrainvillea nigricans Decaisne	*Sargassum natans* (Linnaeus) weyen
Acetabularia crenulata (Lamouroux) Kuntze	*Sargassum fluitans* Borgesen
Neomeris annulata Dickie	*Sargassum polyceratium* Montagne
	Zonaria variegate (Lamouroux) C. Agardh

The fill required for the area behind the bulkhead will come from the vicinity nearest the Ragged Keys. This means that all the algae zone on the seaward side and most of the dense *Thalassia* bed to the west will be dredged to a depth of ten or more feet. It is doubtful whether the deepened area would ever again support either algae or eel grass since depth and substrate required by both would be destroyed.

In areas removed from the immediate effects of dredging, some algae and eel grass will undoubtedly be destroyed by siltation caused by dredging.

The future distribution of marine plants will depend upon the configuration and character of the bottom as currents shift and create new channels and shallow tars.

FISHES

The tide channels between the Ragged Keys and the shallow, grassy flats surrounding them support numerous species of fish (Table 3).

Table 3. Check list of the fishes that have been collected in the immediate vicinity of the Ragged Keys.

COMMON NAME	SCIENTIFIC NAME
Blue striped grunt	*Haemulon sciurus*
French grunt	*Haemulon flavolineatum*
White grunt	*Haemulon plumieri*
Sailors choice	*Haemulon parra*

Caesar grunt	*Haemulon carbonarium*
	Pseudoscarus coelestinus
Rainbow parrotfish	*Pseudoscarus guacamania*
Blue parrotfish	*Scarus caeruleus*
Green parrotfish	*Sparisoma viride*
	Coryphopterus glaucofraenum
Striped goby	*Germania macrodon*
Fat goby	*Gobiosona robustum*
Whitehurst's jawfish	*Opisthognathus whithursti*
Pike blenny	*Chacenopsis ocellata*
	Stathmonotus stabli
Hairy blenny	*Labriscmus nuchipinnis*
Marbled clinic	*Paraclinus marmoratus*
	Paraclinus nigripinnis
Banded clinic	*Parclinus fasciatus*
Brotula	*Ogilbia cayorum*
Holbrook's cuskeel	*Phidion holbrooki*
Black mullet	*Mugil cephalus*
Silver mullet	*Mugil trichodon*
Sea robin	*Prinotus scitulus*
Toadfish	*Opsanus beta*
Clingfish	*Gobiesox strumosus*
	Acyrtops beryllinus
Cowfish	*Lactophrys tricornis*
Smooth trunkfish	*Lactophrys trigonus*
Brown demoiselle	*Pomacentrus fuscus*
Mapo	*Bathygobius soporator*
	Bathygobius curacao
Spotted worm eel	*Bathygobius mystacium*
Blue tang	*Myrophis punctatus*
Ocean Surgeon	*Acanthurus caeruleus*
Doctor fish	*Acanthurus bahianus*
Common barracuda	*Acanthurus chirurgus*
Fringed filefish	*Monacanthus hispidus*
Hairy filefish	*Monacanthus ciliatus*
Broad mojarra	*Gerres cinereus*
Common mojarra	*Eucinostcmus gula*
King mackerel	*Sccmbermorus regalis*
Spanish mackerel	*Scombermorus maculatus*
Blue runner	*Caranx crysos*
Bar jack	*Caranx ruber*
Crevalle jack	*Caranx hippos*
Gray snapper	*Lutjanus griseus*
Lane sanpper	*Lutjanus synagris*
Schoolmaster	*Lutjanus apodus*
Spotted weakfish	*Cynoscion negulosus*
Halfbeak	*Hemirhamphus brasiliensis*
Needlefish	*Strongylura notata*
Spiny toxfish	*Chilomycterus schcepti*
Thread herring	*Opisthonema oglinum*
Queen angelfish	*Holacanthus ciliatus*
Blue angelfish	*Holacanthus isabellita*

Table 3. Check list of the fishes that have been collected in the immediate vicinity of the Ragged Keys (cont.)..

COMMON NAME	SCIENTIFIC NAME
Black angelfish	*Holacanthus aureus*
French angelfish	*Holacanthus paru*
Foureyed butterflyfish	*Chaetodon ocellatus*
Butterflyfish	*Chaetodon capistratus*
Butterflyfish	*Chaetodon striatus*
Butterflyfish	*Epinephalus striatus*
	Epinephalus morio
Spotted jewfish	*Promicrops itaiara*
Three spined soapfish	*Rypticus saponaceus*
Sandperch	*Diplectrum formosum*
Spadefish	*Chaetodipterus faber*
Two lined cardinalfish	*Apogon binotatus*
Spotted cardinalfish	*Apogon maculatus*
False spotted cardinalfish	*Apogon pseudomaculatus*
Conchfish	*Apogonichthys stellatus*
Lookdown	*Selene vomer*
Leatherjacket	*Cligoplites saurus*

Ladyfish	*Elops saurus*
Bonefish	*Albula vulpes*
Striped ribbonfish	*Eques pulcher*
Cubbyu	*Eques acuminatus*
Ribbonfish	*Eques lanceolatus*
Pinfish	*Lagodon rhomboides*
	Archosargus rhomboidalis
Chub	*Kyphosus sectatrix*
Spanish hogfish	*Bodianus rutus*
Common hogfish	*Lacnolaimus maximus*
Slippery dick	*Halichoeres bivittata*
Variegated wrasse	*Halichoeres garnoti*
Pudding wife	*Halichoeres radiata*
Blue head	*Thalassoma bifasciatum*
Dwarf wrasse	*Doratonotus megalepis*
Dusky squirrelfish	*Holocentrus vexarius*
Sergeant major	*Abudefduf saxatilis*
Rock sergent	*Abudefduf taurus*
Spotted moray	*Gymnothorax moringa*
Green moray	*Gymnothorax firebris*
Hardhead silversides	*Atherinomorus stipes*
Round stingray	*Urolophus jamaicensis*
Spotted moray	*Gymnothorax nigromarginatus*
Dwarf seahorse	*Hippocampus zosterae*
Smooth puffer	*Spheroides spengleri*
Mojarra	*Eucinostomus lefroyi*
Bluefish	*Pomatomus saltatrix*

In general, the larger fish stay near the confines of the deeper channels during the daytime and make early morning and late evening excursions to the grass flats for feeding. The grass flats are the nursery grounds for many valuable species such as the spotted weakfish, the snappers, the groupers, the grunts, redfish, as well as the less well known but beautiful and interesting demoiselles, gobies, blennies, scorpion fish and cardinal fishes.

Its channels through the Ragged Keys, particularly those between Ragged Keys 1, 2, and 3, support sizeable groups of reef fishes that are seldom encountered inside the outer reef. The channels are also used extensively by offshore forms in their periodic invasions of the bay. Such fish as the jacks, painted and spotted mackerel, bluefish, blue runner and larger offshore species of snappers are often taken by fishermen in the cuts.

The grass flats also support a large assemblage of fishes. These are smaller but important food fishes - the grunts, the mojarras, the sandperch and mangrove snapper. The reduction of the habitat by filling will automatically reduce the number of fish available through loss of feeding and breeding grounds.

INVERTEBRATES

The Ragged Keys, from the high water mark to the deepest parts of the channels, support large numbers of species of invertebrates (Table 4).

The outstanding feature of the invertebrate assemblage is found in the gorgonian colonies of the tidal channels between the keys and on the ocean side. This is one of the most dense and extensive beds of sea fans End sea whips in the inshore waters of Dade County and they will be completely covered by the proposed dredging.

The invertebrates listed in Table 4 have been classified as to their environment; 29.6% occur in the grassy flats while the majority (70.4%) live on the key rock or immediately adjacent to the keys. Dredging will cause total destruction of numerous species within the area since their ecological requirements will be covered or removed.

SUMMARY

1) The Ragged Keys and the marine environment immediately adjacent to them support a rich and varied group of plants and animals .

2) Currents have, by their sorting of the substrate created any ecological niches not usually found inside the outer reef.

3) Consolidation of the Ragged Keys will destroy the charmers no`/ extensively utilized by charter and private fishing boats.

4) The proposed bulkheading and filling will cause a shift of currents to the north and south around the fill. This will cause scouring and the redistribution of bottom material beyond the immediate dredge and fill zone. Such change will probably be of long term duration, hence no accurate prediction of biological effects are possible-. Recolonization of the affected area will depend upon the rapidity with which currents stabilize the bottom conditions.

Table 4. Check list of the invertebrate animals that are known to occur in the vicinity of the Ragged Keys.

PORIFERA (Sponges)	
Tedenia ignis	On rocks below low waterline
Haliclona viridis	On rocks in channels
Speciospongia vesparia	Deep channels West Ragged Keys
Ircinia campana	On rocks in channels
Ircinia fasciculata	On rocks in channels
OCELENTERATA (Hard corals)	
Porites porites	Quiet shallows around Ragged Keys
Porites furcata	Quiet shallows around Ragged Keys
Siderastrea siderea	*Thalassia* and algae flats
Siderastrea radians	*Thalassia* and algae flats
Diploria clirosa	Gorgonian beds between the Keys
Manicina areclata	*Thalassia* flats west of Ragged Keys
COELENTERATE (Soft corals)	
Pterogargia anceps	Tidal channels between Keys
Plexurella dichotimus	Tidal channels between Keys
Pterogorgia citrina	Tidal channels between Keys
Eunicea calyculata	Tidal channels between Keys
Zooanthideans)	
Zoanthus socialis	Intertidal
Condylactis gigantea	
POLYCHAETA	
Hermodice carunculata	*Thalassia* flats
Folythoa vermicularis	Algae zone, ocean side of Keys
Spirorbis sp.	
Amphinome jamaicensis	*Thalassia* flats, ocean side of Keys
MOLLUSCA (Gastropods)	
Cerithium literatum	Common in shallows (all areas)
Nerita tesselata	Intertidal
Tethys dactylomela	Algae zone, ocean side of Keys
Diadora listeri	
Batillaria minima	All areas adjacent to Keys
Astraea americana	*Thalassia* flats
Aplysia dactylomela	*Thalassia-Potites* zones of Keys
Nerita versicolor	Intertidal
Thais patula	Intertidal
Fasciolaria gigantea	*Thalassia* flats
Strombus gigas	*Thalassia* flats
Siphonaria pectinata	Intertidal
Modulus modulus	*Thalassia* and algae zones of Keys
Turbo castaneus	*Thalassia* flats
Cantharus tinctus	Algae zone, ocean side of Keys

Table 4. Check list of the invertebrate animals that are known to occur in the vicinity of the Ragged Keys (cont.).

Pelecypoda)	
Mytilus exustus	Algae zone, ocean side of Keys
Pedation alata	Intertidal
Codakia orbicularis	*Thalassia* flats
Arca garoala	*Thalassia* flats
Atrina serrata	Algae zone, ocean side of Keys
Laevicardium laevigatum	*Thalassia flats*
AMPHINEURA (Chitons)	
Acanthopleura granulate	Intertidal on rocks
Ischnochiton floridanus	Intertidal on rocks
ECHINODERMATA	
Ophiuroidea (Brittle starfish)	
Ophiothrix oerstedii	All areas below low tide
Echinoidea (Sea urchins)	
Clypeaster rosaceus	*Thalassia* flats
Lytechinus variegatus	*Thalassia* flats
Tripneustes esculentis	*Thalassia* flats
Echinometra lucunter	Intertidal in rocky shore
Diadema antillarum	Gorgonian beds in channels
Holothurcidea (Seasquirts)	
Holothuria floridana	*Thalassia* flats adjacent to Keys
Asteroidea (Starfish)	
Echinaster viridis	All areas adjoining the Keys
CRUSTACEA	
Cirrepedia (Barnacles)	
Tetraclita squamosa stalactifera	Intertidal
Isopoda (Isopods)	
Ligia baudiniana	Above high tide
Decapoda (Shrimps and Crabs)	
Microphyrys bicornutus	*Thalassia* flats
Panulirus argus	Channels between Keys
Callinectes sapidus	Deep channels west of Keys
Penaeus duorarum	*Thalassia* flats
Tozeuma carolinensis	*Thalassia* flats
Stomatopoda (Mantis shrimp)	
Gonodactylus oerstedii	Ocean side of keys
Pseudosquilla ciliata	Ocean side of keys

5) A shift in current patterns will probably create conditions of greater extremes in salinity and temperature that now prevail in the Featherbed Rank region of Biscayne Bay.

6) The marine environment ever the considerable area involved in the fill will be destroyed by dredging operations.

7) Reduction of the tidal channels and grass flats will reduce the areas available for many fish.

8) Reduction of water exchange through closure of the tidal channels may eventually lead to conditions of biological poverty such as those now found in north Biscayne Bay.